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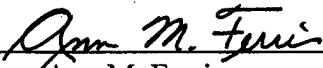
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Master of Science Thesis

MEASURING HOUSEHOLD FOOD INVENTORY WITH A UPC SCANNER IS A
FEASIBLE METHOD OF STUDYING FOOD USAGE PATTERNS IN LOW
INCOME HARTFORD FAMILIES

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2003

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Measuring Household Food Inventory with a UPC Scanner is a Feasible Method of Studying Food Usage Patterns in Low Income Families

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This study determines the feasibility of using a UPC scanner to record the home food inventory of limited-resource families. Feasibility is based on the accuracy of the scanner, time involved, and researcher/study participant feedback. Program staff used a traditional line-item inventory approach to record 19,834 food items during 95 separate home visits of 36 families. Researchers used the UPC scanner to record 5,920 food items, 30% of the total home food inventory. A subsequently resolved data transfer error resulted in the loss of a small number of additional food items scanned. The scanner accuracy measured 96.6% (5661/5920) and offered a 31.8% timesavings over the traditional line item inventory approach. Researchers reported the UPC scanner to be easy to use and less time consuming than a written food inventory and participants reported that scanning food items was non-intrusive. The UPC scanner is a feasible method of recording the home food inventory—the accuracy and simplicity of this approach can provide useful information on foods available for consumption within a home.

Supported by the USDA/NRI Seed Grant # CONS 202-01003, USDA/FNS Food Stamp Nutrition Education Funds sub-contracted through the Connecticut Department of Social Services, and the University of Connecticut Graduate School Faculty Grant.

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Chapter 1: Introduction

1.1: *Statement of the Problem and its Significance*

Food stored within the home represents the primary source of food available for immediate consumption; the pantry, refrigerator, and freezer supply the most readily available source of food for a household. A study “Trends in food locations and sources among adolescents and young adults,” indicates that despite an increase in “eating out” most of a person’s daily nutrition intake comes from foods within the home (Nielsen, Siega-Riz, & Popkin, 2002). Food expenditure data indicate that 61.5% of food expenditures is made for food “at home” while 38.5% of food expenditures is made “away from home” (Kenkel & Ray, 1992). The study of foods purchased, stored, and consumed at the home level can provide a foundation of knowledge on the function of a food system in the context of a community or household.

Inherent difficulties in measurement of the home food inventory limit its widespread use. The time commitment involved in hand recording and analyzing all the foods within a home is prohibitory. A major component of the time involved in collecting home inventory data is the level of detail required. For example, it may take many hours to record the food name, manufacturer, and evidence of specific ingredients such as the presence of iron fortificants in a large inventory. Additionally, measurement of home food inventory is an intrusive method for gathering data. Families may view

researchers searching through cabinets, freezers, refrigerators, and other food storage locations as intrusive and not permit the inventory. An alternative approach to the handwritten line-item inventory is the use of a UPC scanner to record the home food inventory. Although this approach does require inspection of the entire food inventory and thus may still be viewed as intrusive.

Researchers will use UPC scanning technology to determine if this technique is an accurate and feasible method for recording the home food inventory. This method involves scanning the UPC code for each food in the home inventory then uploading the stored codes, matching to a food name and manufacturer within a managed database and generating a line-item report of all foods in the home. A generic scan code is used to record foods without a UPC such as produce and meat. For example, produce often does not have a UPC but a generic code for apples can be generated and stored in a book. If needed, a researcher scans the symbol in the book in place of an actual UPC on the food item. This process is often used in supermarkets and grocery stores for sales of items that are weighed or measured. After scanning the home food inventory, an analysis of inventory size as well as specific food group distribution can be reported. A line item inventory requires intensive hand written records of all foods in the home. The potential for transcription errors exist, as the process requires laborious hand recording of all foods in the home. Conversely, the UPC scanner data are quickly and accurately upload to a computer database, matched with a product and manufacturer, and the output formatted for printing. Ultimately, the hand held UPC scanner holds the potential for being a rapid and accurate method of recording and reporting household inventory data.

1.2: *Research Goals*

Researchers will determine if the UPC scanner (AirClic® Inc, Bluebell, PA) is a feasible method of recording home food inventory in low-income families. Feasibility is assessed in terms of the accuracy of the UPC scanner output, the time efficiency of the scanning and report generating process, the usability of the scanners to complete the task, and the ability to gain access to a family's food inventory. The specific research questions are as follows:

- Is a handheld UPC scanner a feasible tool to record and report the household food inventory of low-income families residing in Hartford, CT? The feasibility of the UPC scanning technique is assessed as a measure of time saved and accuracy of the UPC scanner.
- Will researchers be able to gain access to the household inventory?
- Will participant response to scanning the home inventory be positive?

Chapter 2: Literature Review

2.1: Community and Household Food Systems

The household food system can be viewed as a subsystem of a community food system. Gillespie & Gillespie (2000) describe the community food system as part of a larger network, geographically located within a community and comprised of several properties: self-reliance, control, accessibility, healthfulness, safety, sustainability, resilience, and food security. The same principles that comprise the community food system can be used to describe the food system at the household level. For example, households with an adequate supply of acceptable foods to feed the entire family are viewed as having a functioning food system. Conversely, families with inadequate food supply are viewed as having a dysfunctional household food system. In this context, the food within the household becomes an integral component of the household food system.

Within the household food system, families strive to maintain an adequate food supply to support the needs of the household. Gillespie and Gillespie (2000) describe the reliance of the family unit on food resources within the home. They state, "The family unit has been described as any configuration of people who regularly eat together or from the same household food resources, and who mutually influence decisions about food." However, in a dysfunctional household food system, how family members influence decisions about food has yet to be described. Regardless of the functioning status of the household food system, the food resources available to a family directly represent a family's ability to meet their nutrition needs.

The food procurement methods that a limited-resource family employs are diverse and may include: community food retailers (large and small markets), food assistance programs such as the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) and the Food Stamp Program managed by the Food and Nutrition Service (FNS) of the US Department of Agriculture (USDA), gifts from family or friends, as well as that food which may be grown or stolen (**Figure 1**). Kempson, Keenan, Sadani, & Rosato (2002) studied the food procurement practices of low-income families in New Jersey; the authors eloquently described limited-resource families reliance on food procurement options, such as: selling surplus food, switching price tags on food, purchasing food from private individuals, and seeking out and using road-kill. The functional capacity of the household food system is a summative measure, that is, families utilize multiple sources to garner food. Food procured may be stored in the home for later consumption or may be consumed out of the home such as at a restaurant establishment or at another residence such as at a family or friends house. Those foods available within the home form the primary resource for meeting ongoing daily nutrition requirements of family members and may also be used to supply nutrition to close relatives and friends. Additionally, the food resources within the household serve as a proxy measure of determinants of food security such as access and acceptability of food. The relationship between a family's access to food and their ability to meet their nutrition needs forms the concept of a functional household food system and the study of food security.

2.2: Food Security

The term food security describes the myriad of factors associated with the ability of a family to have food. In 1990, an expert panel convened by the Life Sciences Research Office (LSRO) of the Federation of American Societies for Experimental Biology (FASEB) developed a definition for food security and what constitutes food insecurity (Life Sciences Research Office (Anderson SA ed.), 1990). They stated:

"Food security is access by all people at all times to enough food for an active healthy life and includes at a minimum: a) ready availability of nutritionally adequate and safe foods, and b) the assured ability to acquire acceptable foods in socially acceptable ways. Food insecurity is the limited or uncertain availability of nutritionally adequate and safe foods or the limited or uncertain ability to acquire acceptable foods in socially acceptable ways."

Inherent in this definition is the ability to measure a family's success at having both "access to" and "acceptable" foods. The foods available in a household provide direct evidence of a family's access to food. It is important to note, that the presence of food in the home provides no information about the procurement method. It is reasonable to imagine a scenario in which food was given as a gift, procured through a social service program, or stolen—none of which indicates ready access to food. However, a report of foods within the home such as a line-item inventory can be used to question the procurement source, mechanism, and consumption frequency of individual food items.

In an attempt to quantify the degree of food security within a household, researchers have developed several tools useful in determining the presence and degree of food insecurity. Wehler (1987) developed a food security screening tool through research with the Community Childhood Hunger Identification Project (CCHIP). This project sought to better define hunger among families and children. This instrument is a scale of eight questions that describe the extent of food insufficiency due to inadequate resources. Radimer, Olson, Green, Campbell, & Habicht (1992) developed a survey with thirty questions and three scales for household's, women's, and children's hunger. Researchers found the scales to be valid indicators for measuring hunger at the household level. However, to better ascribe food insecurity statistics at the population level, the USDA developed a food security survey instrument for administration by the US Census Bureau (Hamilton et al., 1997). The USDA survey instrument is a three-part tool that offers an efficient method of screening households for food insecurity and hunger (Bickel, Nord, Price, Hamilton, & Cook, Revised 2000). This food security evaluation instrument poses questions aimed at determining a family's access to safe and acceptable foods. The questions follow a pattern that identifies increasing food insufficiency within the household. For example, early questions assess the adequacy of resources available to purchase food; later questions determine if food insufficiency has affected children in the family.

Using the USDA food security module, researchers follow the US food insecurity measures on an annual basis. Recent census data reveal that nearly 11 million households (10% of all US Households) were food insecure at some time during the

previous year (Nord et al., 2002) Income remains the most significant predictor of food insecurity in the United States. A recent population survey of US Households indicates that those households with annual income below 185% of the poverty level are six times more likely to be food insecure and eight times more likely to be hungry compared to households above this commonly used poverty estimate (Andrews, Nord, Bickel, & Carlson, 2000). Low-income households with children were especially vulnerable to food insecurity more so than households without children (40.3% versus 26.1 %). A study of low-income residents in Hartford, CT revealed 52% of study participants experienced some level of food insecurity and 24% hunger in the previous 12 months (Martin, 2002). Martin also demonstrated that food insecurity among neighborhoods within Hartford, CT differ significantly and may be related to community integrity measures such as social capital. This study highlights the severity of food insecurity in low-income urban families and the disparity seen between neighborhoods in the same urban area. However, low-income families are not the only households subject to food insecurity. Recent data indicate that food insecure households in middle-income families are on the rise (Nord & Brent, 2002). A family with ready access to acceptable foods, by definition, should appear food secure; however, often a family with access to foods may still be food insecure due to the unacceptability of the food products procured.

The presence or absence of foods in the home and their procurement method are components of household food security and a functioning household food system. Data gathered on foods in the home complement analysis of household food security and help researchers further understand how limited-resource families meet their nutrition needs.

2.3: Estimating Food Procurement and Storage Patterns.

Measurement of food consumption patterns can span a continuum between food procurement and consumption. At the procurement level, aggregate supermarket data are used to assess changes in purchasing patterns. Because of the multiple food procurement options for a family (e.g. large market, small market, bodega, corner store, or other) it is difficult to correlate changes in aggregate sales with individual purchaser characteristics.

Kirlin & Cole (1999) determined the feasibility of tracking products purchased with food stamp benefits and link it to the demographic information of the food stamp household that purchased the food. This study, conducted in Georgetown County, South Carolina, recruited 11 food retail stores (7 large supermarkets with UPC scanning units and 4 small grocery or convenience stores without UPC scanners) and collected data from September through October 1997. Researchers provided scanning capability to stores without the UPC scanning equipment; the cost of system setup was considered in determining the overall feasibility of the project. The UPC scanner data matched 96-98% of the transactions from food stamp recipients. Nearly 34,000 unique items were scanned at the 11 stores in the study, although 26% of all food stamp redemptions occurred in stores that lacked scanning systems. Researchers were able to link food stamp purchases with household characteristics across broad food groupings, such as meat and dairy, as well as food categories such as red meat and poultry. Additionally, purchasing patterns for food items, size, manufacturer versus generic brand, and cost were all recorded. These investigators concluded that the technical ability of linking supermarket data with household demographics exists, but cited several obstacles to data collection including

the willingness of supermarkets to provide the necessary sales data. Additional difficulties included: the high cost of providing UPC scanning systems to stores without such scanning devices, difficulty gaining support of food retailers, and the unwillingness of some retailers to provide proprietary sales data such as foods purchased at no cost. These investigators also pointed out that the loss of data due to telecommunications errors was common and that checkout procedures added to the regular routine of cashiers were not diligently followed during busy times and thus, may have negatively affected data collection during critical periods of supermarket sales. These researchers highlight that the additional workload placed on supermarket checkout cashiers may be viewed as unacceptable and thus impacts the integrity with which data collection procedures are implemented. In addition to the feasibility of data collection, usefulness of the data must also be addressed.

The critical impediment to using aggregate supermarket sales data to study food-purchasing behavior is the multiple food procurement options a limited-resource family may employ. Kirlin et al (1999) found that nearly 26% of all food stamp benefits are spent in smaller stores without scanning systems. This corroborates findings by Kaufman (1999) highlighting that nearly 60% of food stamp benefits in rural poor are redeemed at small supermarkets and grocery stores and not at large supermarkets. Additionally, the reliance on any particular food procurement source is variable; price, availability, proximity, and need all contribute to a person's decision to procure food resources. Because of the varied source of food acquisition, especially in limited-resource families,

data gathered at large supermarkets are often limited to providing aggregate changes in sales of foods.

Despite the shortcomings of aggregate sales data, there are several key uses for this type of information. The US Department of Labor, Bureau of Labor Statistics, produces the Consumer Price Index (CPI) on a monthly basis; the CPI is the average cost of a collection of goods that a consumer can expect to pay. One major category of the CPI is food and beverages and aggregate sales data for foods such as breakfast cereal, milk, coffee, chicken, wine, full service meals and snacks (US Dept of Labor, 2003). Another aggregate marker of food sales is food consumption data, used by the USDA \ Economic Research Service to calculate food consumption supply and use. The ERS annually calculates food disappearance data for the amount of food available for consumption in the US by tracking several hundred agricultural commodities within the food system (USDA/ERS, 2001). The data provide a measure of the flow of raw and semi-processed food commodities through the U.S. marketing system. As food moves in and out of procurement sites within the community, aggregate food sales describe the ebb and flow of food available within the community food system. However, as Kirlin et al (1999) concluded, linking aggregate sales data to household and individual characteristics is more difficult. The alternative to recording food data at the procurement site is to identify the foods within the home.

Measuring food availability in the home is a practical and valid approach to monitoring dietary behaviors, food security, commodity food use, food expenditures, and food system descriptions in community-based studies of low-income families (Patterson,

Kristal, Shannon, Hunt, & White, 1997). The benchmark for home inventory is the line-item inventory of all foods available within the home. Researchers have based the accuracy of their estimation instruments to the researcher inspection of the complete home food inventory (Crockett, Potter, Wright, & Bacheller, 1992). We were able to find only a single study reporting the use of a complete line-item food inventory, as the primary data collection method to describe food consumption patterns in the home (Turrini, Saba, Perrone, Cialfa, & D'Amicis, 2001). In this Italian study, researchers recorded the presence or absence of foods stored in the household pantry. Although the authors rely on the collected line-item inventory, there was no mention of the time commitment involved in collecting this information. Because of the time and resource intensive nature of completing a complete line-item food inventory in the home, researchers have developed estimation tools to describe the presence of foods and food categories without recording all foods in the home.

Estimation tools require the household respondent to identify the presence or absence of key food items or food groups within the home. Crockett et al. (1992) developed and validated a self-reported food inventory listing 80 foods in 12 categories to detect the presence or absence of foods that reflect the dietary guidelines for reducing the risk for cancer. Additionally, foods and food groups in the data collection instrument have been refined to target dietary guidelines for foods purchased by persons with diabetes (Miller & Edwards, 2002) and to low-income black and Hispanic clients (Beto, Sheth, & Rewers, 1997). Instruments that estimate the presence or absence of specific foods and food groups within the home are useful in identifying changes in shopping and

food consumption practices. Although these estimation tools have been validated in several environments, shortcomings exist.

The data instruments track breadth of the food inventory, that is, the presence of food items, but lack the precision to track the depth in food inventory, or the number of food items present. Another concern is that using estimation models assume that the food characteristics are distinct. For example, asking the question “do you have milk or milk products in the house?” may elicit different responses from individuals with different perceptions of what foods milk products comprise. Furthermore, the strategy of tracking the presence or absence of only specific foods or food categories limits the conclusions that may be drawn. Researchers must still view the recording of the entire home food inventory as the benchmark measurement for foods within the home.

2.4: Collecting home food inventory data as a measure of functional success in the family food system

For the low-income family, food in the household is gathered through a system of available resources. Figure 1 reflects many of the food procurement options available to a limited resource family, including: foods purchased with currency or coupons, stolen, donated, gathered, grown, bartered or traded, or given as gifts from family or friends. Home food inventory provides direct evidence of food available to a family and thus can provide insight to the level of access a family has to procuring food items. Furthermore, analysis of the turnover of items in the home food inventory can provide key evidence of the acceptability of foods readily available to a family. This is significant because a

primary source of a family's nutrition is from food available within the home inventory. Home inventory is not the only source of food available to a family; researchers can gather data on the use of other food procurement sources, such as restaurants, food pantries, schools, and relatives, using focused interviews and questionnaires.

Measuring the adequacy of foods in the home inventory can take several directions. Although a total count of foods items in the home may be useful, it does not derive an answer for the underlying question, "is the home food inventory adequate to support the family's nutrition needs." To answer this, the definition of a family must be derived and the food inventory needs to be analyzed in some fashion; one obvious manner is to simply record the nutritive content of one serving of a food item in the inventory. Other methods include a more intensive measurement of how often foods are used, scoring foods based on food groups or "healthfulness," or rating foods based on frequency of use. A family can provide food consumption frequency by indicating which foods are consumed frequently and which foods remain on the shelf indefinitely. Analysis of food inventory can also provide data on food ingredients and food fortificants consumed. Careful study of the home food inventory can provide significant insight into the nutritive quality of a family's food stores as well as provide supporting evidence to assess food security.

2.5: UPC Scanning Technology

In the early 1950's researchers began to develop and use optical readers that could record a dual colored pattern and convert to a numeric signature. Originally the

technology was used to track railroad cars and by the early 1970's, optical readers or "scanners" were able to accurately read a series of vertical lines (black and white) that identified a product (Wright, 2000). Because of the widespread success of such symbols, nearly all products sold in the United States now contain a Universal Product Code (UPC) individual to the product itself. The Uniform Product Code Council (Uniform Code Council Inc; Dayton, Ohio) (UCC) directs the use of UPC's in the US in conjunction with EAN International, an organization headquartered in Brussels, Belgium. Between UCC and EAN, over 800,000 companies worldwide and their products have unique product codes that can identify the company and an individual product (Uniform Product Code Council, 2003). Since the rapid adaptation of the UPC from its early introduction in the 1970's, the current twelve-digit format has garnered worldwide acceptance. The twelve-digit UPC actually breaks down into a six-digit company identifier; the first number of this is a product category identifier, the next five digits are the product identifier. The final number is a "check" digit that is calculated from the previous eleven by summing the digits in odd positions and multiplying by three—then summing the digits in the even position and adding this to the result of the previous equation. The final number is then analyzed; the resulting sum that would need to be added to that result to make a number divisible by 10 is the "check digit" (See Appendix A for an example).

2.6: Using UPC Scanning Technology to track food system information

Measuring home food inventory could begin at the supermarket as most small to large supermarkets use UPC codes. However because there is no definitive method of linking foods purchased to the person purchasing the food, aggregate supermarket data are only useful in identifying food sales for that specific institution. Some investigators have attempted to use supermarket purchase receipts to measure the success of nutrition interventions aimed at the “point-of-purchase” and indicate a potentially viable data collection method (Levy, Mathews, Stephenson, Tenney, Schucker, 1985; Levy & Stokes, 1987). Application has not extended to studies within a specific subset of the supermarket population because of the difficulty in identifying who purchases a food item. Therefore, at the supermarket level, matching food-purchasing behavior with a specific person has yet to be accomplished. Mela, Aaron, & Getenby (1996) undertook an application of using supermarket receipt data as researchers interviewed shoppers before and after purchasing food. Researchers collected the store receipts, questioned the study participants about whether there was an intention to purchase a food prior to entering the supermarket, and were able to make conclusions about the relationship of food purchasing behavior in people with different levels of hunger. Although this type of research is helpful in studying personal habits in a pre- and post-shopping environment, it does not provide useful information on foods available at the household level since food procurement methods are numerous.

Kirlin et al (1999) showed that it would be feasible to link supermarket sales data with food stamp recipient data. However, the lack of cooperation by some supermarkets,

and the finding that nearly one quarter of all foods purchased by food stamp recipients is not purchased at supermarkets, but rather at convenience stores, indicates that this method of monitoring foods purchased may not be cost effective. These findings are significant because the process of using UPC codes to track food consumption patterns of an individual through food stamp purchasing data lends credence to the idea of using inexpensive UPC tracking tools to record foods in the home.

2.7: Summary—Linking Home Food Inventory, UPC Scanning, and the Household Food System

The process of tracking inventory with an optical UPC reader has become ubiquitous throughout supermarket sales in the US. However, despite widespread use of UPC scanning technology by supermarkets and businesses to track inventory, sales, and product use, researchers rarely use this technique to gather household level data for food stock or other inventory items. As previously described, foods purchased and stored in the home inventory become the primary source of food available to a family; thus, food consumption is closely linked to purchasing patterns.

Nutrition experts often use changes in purchasing patterns as a measure of success for a nutrition program. It is easy to imagine that over emphasis of measuring foods purchased will lead to data collection bias, as large supermarkets become the easiest domain in which to collect this type of data. However, as Kempson et al (2002) have illustrated, limited resource families utilize many options other than the large supermarket to procure food. Thus, measuring food at the procurement point would be a

difficult endeavor as researchers would need to be represented at all the food purchasing points.

Measuring food at the home level bypasses this difficulty since foods in the home represent the sum of all procurement methods. The report of foods within the home can be used to describe specific procurement sources as well as nutritive adequacy of the foods available for consumption. Researchers have taken a minimalist approach to measuring home food inventory using tools that estimate the presence or absence of only a select few food items or groups. In contrast to these estimation techniques, a rapid method of measuring the entire home inventory would be the preferable objective measure of the presence or absence of a food in the home. Using a portable UPC scanner to record home food inventories at the household level has not been studied; the feasibility and benefit of this method has yet to be determined.

Chapter 3: Article

Measuring Household Food Inventory with a UPC Scanner is a Feasible Method of Studying Food Usage Patterns in Low Income Families

ABSTRACT

This study determines the feasibility of using a UPC scanner to record the home food inventory of limited-resource families. Feasibility was based on the accuracy of the scanner, time involved, and researcher/study participant feedback. Program staff used a traditional line-item inventory approach to record 19,834 food items during 95 separate home visits of 36 families. The UPC scanner was employed to record 5,920 food items, 30% of the total home food inventory. A subsequently resolved data transfer error resulted in the loss of a small number of additional food items scanned. The scanner accuracy was 95.6% (5661/5920) and offered a 31.8% time savings over the traditional line item inventory approach. The UPC scanner was easy to use and participants reported that scanning food items was non-intrusive. The UPC scanner is a feasible method of recording the home food inventory; the accuracy and simplicity of this approach can provide useful information on foods available for consumption within a home.

KEY WORDS: ● Food Inventory ● UPC Scanner ● Food Security

INTRODUCTION/ BACKGROUND

Foods available within the home comprise the primary source of nutrition for a limited-resource family. Although recent studies suggest that despite an apparent increase in "eating out" most of a person's daily nutrient intake comes from foods within the home (Nielsen, Siega-Riz, & Popkin, 2002). Food expenditures data further support this premise. In 2001, 59% of household food expenditures were made for "at home" foods versus 40% of total household food expenditures for "away from home" foods (USDA/ERS, 2002). In a study of low-income Hartford residents, 79% of households reported rarely eating out, compared to 54% of households with incomes above poverty (Martin, 2002). To best understand food consumption patterns in limited-resource families, it is germane to study the home food inventory.

Researchers study the food system at several levels; the procurement site, such as large supermarkets, offers aggregate food sales information. Conversely, researchers studying changes in individual food patterns may choose to identify foods stored within the household. Levy et al (1985) presented changes in aggregate supermarket sales to illustrate changes in purchasing patterns after a consumer education program. Using supermarket sales data to track specific groups such as food stamp purchases has proved more difficult. Kirlin et al (1999) determined the feasibility of tracking products purchased with food stamp benefits and linked it to the demographic information of the food stamp household that purchased the food. These researchers conclude that it is technically feasible to link food-purchasing data to purchaser characteristics; however, they cited several obstacles, such as the willingness of supermarkets to provide the data,

as prohibitory. Additional difficulties cited by the authors included: added checkout procedures critical to data collection were not always followed during busy times, high cost of supplying UPC scanning technology to stores without UPC scanning cashiers, and the negative view of store managers towards releasing proprietary sales data. One critical concern when using aggregate supermarket sales to study food-purchasing behaviors is the multiple sources of foods purchases.

Kirlin et al (1999) found that nearly 26% of all food stamp benefits are spent in stores without scanning systems. In a study of limited-resource families in New Jersey Kempson et al (2002) described the varied practices used to acquire food or money for food such as: the sale of surplus food, switching of price tags on food, purchasing food from private individuals, and seeking out and using road-kill. Because of the varied source of food acquisition, especially in limited-resource families, data gathered at large supermarkets are often limited.

An alternative method is to study the home food inventory. This has been shown to be a practical and valid approach to monitoring dietary behaviors, food security, commodity food use, and food system descriptions in community-based studies of low-income families (Patterson, Kristal, Shannon, Hunt, & White, 1997). Researchers have described several techniques for recording and analyzing home food inventory. A traditional food inventory requires visual inspection and recording of each food item in the home. We were able to find only a single study reporting the use of a complete line-item food inventory to describe food consumption patterns (Turrini, Saba, Perrone, Cialfa, & D'Amicis, 2001). To reduce the time involved, others have assigned food

items to groups in order to describe the presence or absence of food categories in the home. Several instruments that estimate the presence of food items in the home (shelf inventories) have been reported as sensitive and valid instruments to assess household food purchases (Crockett, Potter, Wright, & Bacheller, 1992). Additionally, foods and food groups in the data collection instrument have been refined to target dietary guidelines for reducing the risk of cancer (Crockett et al., 1992), foods purchased by persons with diabetes (Miller & Edwards, 2002), and to low-income black and Hispanic clients (Beto, Sheth, & Rewers, 1997). Clearly, shelf inventories are a useful tool to estimate the presence or absence of specific foods and food groups within the home. Although these estimation tools have been validated in several environments, shortcomings exist. The data instrument is designed to track breadth of the food inventory, that is, the presence of food items, but lacks the ability to track the depth in food inventory, or the number of food items present. Furthermore, the strategy of tracking the presence or absence of only specific food items or categories limits the conclusions that may be drawn from the data gathered. Subject response must always be viewed as subjectively collected information. Researcher collected line item inventory must still be viewed as the benchmark.

A novel approach to measuring home food inventory in an objective manner is the use of the UPC scanner. The scanning device may speed up the home food inventory data collection process to the point that completion of a home food inventory would become a cost and time effective approach to data collection. The objective of this study

was to test the feasibility of recording the home food inventory in limited-resource families using a UPC scanner system.

METHODS

The Sample:

This is an observational study designed to compare two different data collection techniques, using a UPC scanner versus a traditional line item inventory, to collect and report home food inventory. To measure timesavings offered by the UPC scanner technique a sub-study was conducted on 6 household food inventories.

Participants for this study were recruited from families seeking community anemia screening services at the Family Resource Centers (FRCs) in Hartford, CT. FRCs serve limited-resource families residing in cultural subsections of the city. Families with children aged 24 to 60 months were eligible. This study population assured that the UPC scan of the home food inventory included those families at highest risk for food insecurity; additionally, this ethnically diverse population exposed the scanner and the scanner food database to ethnic foods not commonly seen in large supermarkets. Each family was visited three times in four weeks and paid \$10.00 for each home visit for a maximum of \$30.00 per family.

All procedures have been approved for human participation and informed consent by the University of Connecticut, Connecticut Children's Medical Center, St. Francis/Mt. Sinai Hospitals and the Village for Families and Children, Inc. Participants provided informed and written consent. In the process of obtaining subject consent, researchers

showed each family the scanner and explained the exact process by which we completed the line item and UPC scan of the inventory.

UPC Scanner and Software Used:

We used three UPC scanners and software produced by AirClic® Inc, Bluebell PA. Each scanner holds 160 food items and can upload the stored UPC's to a database managed by AirClic® Inc. The UPC's are matched with manufacturer and product name and a report is generated in hypertext markup language (html) format.

Assessing Feasibility:

The feasibility of using a UPC scanner to record home food inventory was assessed for accuracy, time savings, and researcher and study participant experience. During each of three visits in a four-week period, subject families subjects had their entire food inventory recorded using a handheld UPC scanner (AirClic® Inc, Bluebell PA) as well as a complete handwritten line-item inventory. No foods were intentionally excluded from scanning. Once the UPC scanning was complete, the data were uploaded to the AirClic® Inc. database for matching the recorded UPC with a food and manufacturer. The resulting report was printed and compared with the line-item inventory. A "match" was recorded if the food reported by the UPC scanner output was the same as that on the line-item inventory. The food was considered a "miss" if the UPC scan did not match any food on the line-item inventory. Manufacturer and product size information was presented on the UPC report. The product name and manufacturer were checked against the line-item inventory. Additionally, every food in the line-item inventory database was categorized into 12 food groups (Supplements, Vegetables, Fats & Oils, Legumes / Dry

Beans / Peas / Nuts, Milk and Dairy Products, Grain Products, Eggs, Meat / Fish / Poultry, Fruits, Sugars and Sweets, Spices, and Miscellaneous foods) (USDA/ARS, 2003). Accuracy of the scanner report was calculated as a percentage of correct food matches between the line-item inventory and the UPC scan for each food group as well as the overall mean of matches for all food groups. Additionally, researcher experiences using the handheld scanners were collected, categorized, and reported.

All comments made by the family's regarding the UPC scanner and the success rates of families allowing us to complete the home assessments were reported.

Researchers also noted successful recruiting strategies used to gain access to the family home inventory. The ability to gain access to the family's entire food inventory was considered an essential contributing factor to the feasibility of using the UPC scanner for research purposes.

To calculate time savings for utilizing the UPC scanning technique one researcher scanned a household with approximately 150 food items on six separate occasions. Foods within the household were available in several locations including the pantry, freezer, refrigerator, and other household storage locations. The time to complete the line-item scan was recorded by a second researcher on the same food inventory. Time to scan included the time to complete a scan of the inventory and time to upload and print the data.

Statistical Analysis

Chi-square analysis was conducted to determine if differences exist in demographic variables such as family size and number of children among ethnic groups.

Scanner accuracy was defined as the (number of correctly identified food items) / (total number of scanned items). The result was presented as percentage accuracy for the scanner and represents the accuracy of the data in the scanner database as it is highly unlikely that the scanner itself misread a UPC symbol. Distribution of scanned food items and scanner accuracy among food groups was reported. The errors noted between the scanner and the line-item inventory were further analyzed to determine if any specific food items or groups were missed more often by the scanning technique.

The time to complete the home inventory using the UPC scanner and the line-item inventory was analyzed using an independent students t-test to compare mean time to complete the inventory compared to the mean time to complete the UPC scan of the home inventory.

Qualitative comments made by study participants and researchers on the use of the scanner were grouped into four categories: issues critical to the use of the scanner, non-critical comments on the use of the scanner, suggestions for improving the home inventory scanning process, and comments made by study participants or their family regarding the scanners.

RESULTS

Household Description

Thirty-six families (53% African American, 33% Latino, 11% Caucasian, and 3% not reported) participated. Half of the families reported income levels; the mean monthly income was \$639.54 (SD \pm \$288.90, Range \$0 - \$1200.00). Two-thirds of families (24/36) lived in rental apartments and the remainder rented or owned a house. The

mother was the primary caretaker in 95% of the study sample; one caretaker reported to be the aunt, another, the grandmother. Mean caretaker age was 30 years old ($SD \pm 8.52$, Range 18 to 56 y/o). Three-fourths of family caretakers (27/36) reported being single or divorced. In this sample African-American households were larger than other ethnicities ($X\text{-bar} = 3.6$, $SD \pm 1.4$, $\chi^2 = 35.6$, $p < 0.005$) and Hispanic households had significantly fewer children than Caucasian and African-American households ($X\text{-bar} = 1.43$, $SD \pm 0.56$, $\chi^2 = 17.833$, $p = 0.037$). The mean age of the children in this study was 3.5 years ($n = 43$, $SD \pm 1.2$) and ranged from 1.5 to 5.9 years.

Home Food Inventory

Using the line-item inventory approach, the research team completed 95 home inventories in 36 different families recording 19,834 food items. The UPC scanner was used in 51 home visits in 32 different households to record 5920 food items. The number of foods scanned represents 30% of the entire food inventory. 5661 of 5920 foods were matched on the UPC output with corresponding foods on the line-item inventory. The overall accuracy of the scanner for foods that were uploaded was 95.6%.

Food Group Analysis

Foods were coded from the line item inventory based on USDA food categories (**Table 1**). Inventory composition analysis was completed based on the presence and size of each food group. The three most represented food groups from the line-item home inventory were: the Grain Products group representing 23.6% (4,686/19,834), the Vegetables group representing 19.4% (3,856/19,834), and the Meat, Fish, and Poultry group representing 16.2% (3,218/19,834).

The food group analysis of only those foods scanned (30% of the line-item inventory—5,920/19,834 food items) were as follows: the Grain Products group represented 28.3% (1,673/5,920), the Vegetables group represented 19.1% (1,133/5,920), and the Meat, Fish, and Poultry group represented 13.0% (770/5,920) (**Table 2**).

The accuracy of the scanner output for each food group is presented in **Table 3**. Scanner accuracy for all groups was more than 90% with overall accuracy 95.6%. The three categories with the highest UPC scanner accuracy were the Vegetables (97.7%), Fats and Oils (96.2%), and Legumes, Dry Beans, Peas, and Nuts (96.2%) group. Although supplements scored 100%, there was only a single supplement scanned. The three categories with the most UPC scanner mistakes were the Spices (8.1%), Sugars and Sweets (6.6%), and Fruits group (6.2%).

Time Savings using the UPC Scanner

The mean number of foods in the home inventory used for calculating the time savings by using the UPC scanner was 175.5 foods ($SD \pm 41.79$, range = 121 to 231 foods.) The mean time to complete the line item inventory, 64.5 minutes ($SD \pm 17.24$ min), was significantly longer ($t=9.875$, $p<.000$) than the mean time to complete the UPC scan and generate the output, 44 min ($SD \pm 10.73$ min). This represents a 31.8% time savings when utilizing the UPC scanner over a handwritten line item inventory.

Researcher and Study Participant Comments on the Use of the Scanner

We grouped comments on the UPC scanning process into four categories. Issues critical to the use of the scanner: researchers reported some difficulty scanning mixed dish foods, leftover foods in the refrigerator, and on occasion, foods were unidentifiable

or unknown. Researchers also encountered several occasions where uploaded scanner data were lost as the connection between the researchers computer and the database which matched the UPC code with manufacturer and food item took longer than the server connection allowed; the result was a loss of all data from that scan. This problem was subsequently corrected and no longer an issue for the final months of the study.

Non-critical comments on the use of the scanner included: researchers reported that the beep after each scanned food item could be shortened from the multiple tone signal to a single beep. The scanner should be made to hold more than 160 food items and during the uploading process an option to save the scanner data to a file on a local computer would be helpful. Suggestions for improving the home inventory scanning process were as follows: increase scanner memory to allow a single scanner to hold approximately 400 food items, the option to save scanner data to a local computer, and the option to save scanner output to a database format—currently scanner output is a hypertext markup language (html) file. Comments made by study participants or their family regarding the scanners include: the scanner is not intrusive, appears to be safe, and could be used by the caretaker to scan their own inventory.

DISCUSSION

The UPC scanner is a feasible method of recording the home food inventory in a limited-resource family. The high accuracy of the scanner output (95.6%), the time savings of UPC scanning versus completing a line item inventory (31.8%), and the positive researcher and study participant comments make this technique a reasonable choice when studying the food available within the home.

The three largest USDA food groups found in the home inventory were the grain, vegetable, and the meat, fish and poultry group (Table 1). Although the vegetable group accounted for approximately 20% of food items in the home, it appeared many of these items were stored for long periods of time. In this case, using the food inventory report to inquire about the frequency of consumption of the various vegetables stored in the home could provide key evidence of the acceptability of the foods within the home.

The fifth ranked food group in the home inventory was the Legumes, dry beans, peas and nuts group. We found this somewhat surprising since foods in this group are relatively inexpensive and constitute a fairly rich source of nutrients. However, the findings of the top three groups from the line item inventory (Grain, Vegetables and Meat / Fish / Poultry) correspond with national food consumption survey data from the 1994-96 Continuing Survey of Food Intakes by Individuals (CSFII) showing the top three food groups consumed (by energy) to be the grain, meat, and vegetable groups (USDA/ERS, 2000).

Although we did not scan the entire food inventory of every study participant, we did scan 5920 of 19834 (30%) of foods we encountered in the homes. The distribution of food group size for the scanned food items is similar to that of the total-line item inventory (Table 2) indicating that we scanned a fairly representative sample of all foods in the home. Accuracy of the scanner was also similar between food groups; all food groups were more than 91.9% accurate (Table 3). This suggests that scanner accuracy holds well among all food groups.

Based on this feasibility study, researchers using this tool can expect to miss only 4 to 5% of foods in the home. We tested the accuracy of the scanner output in a rigorous environment, exposed the scanner to numerous ethnic foods, USDA staple food items, and foods regularly prepared in the homes of Hispanic and African American families. Although we did not test the scanner in homes of other ethnic groups, we predict that the scanner output accuracy would be similar.

The limitation to this technique is the process of matching the UPC to a manufacturer and food item. Although many companies possess a database with such information, it is critical that the information be correct. We utilized a scanner, uploading software, and database managed by AirClic® Inc. As AirClic® upgraded its database and uploading process, difficulties encountered when we began the project were corrected. AirClic® receives UPC data from proprietary sources and is constantly updating its information. Although UPC scanning devices are available from numerous sources, we were unable to identify any other retailers that possess a database of foods and manufacturers, and possess the technology to upload the scanned UPC's and generate a report of foods in the home. Additionally, UPC's would be a valuable addition to any food analysis software program. By adding UPC's to foods in analysis software, food, manufacturer and nutritive value of a serving of the food item could be analyzed.

Recruiting Families for Home Inventory Study

The difficulty of recruiting families for a study that requires a fairly intrusive home food inventory evaluation is notable. During the initial recruitment phase of this study, researchers employed 3 basic recruitment strategies. First, all recruitment was

accomplished from families that were seeking anemia screening in local FRCs. An established relationship with families was made through the anemia-screening program and therefore recruitment for the home assessment was made in a comfortable environment. Second, recruitment of friends and neighbors through already successful home assessments was used—participants garnered in this fashion were also referred to the anemia-screening program. Finally, some “cold-calling” and street-side recruitment was used as our presence in the community was noticed and often questioned, when our research team explained the purpose of our community assessment project, families would often request to be included.

We found that without establishing initial rapport with participant families, approximately 1 in 10 families would schedule a home assessment. Only a portion of those would go on to successfully complete the 3 visits in 4 weeks. Once a rapport was established, anemia screening participants interested in the home assessment study were called and scheduled for a home visit; approximately 3 in 5 of those appointments were kept through the first visit.

CONCLUSION AND APPLICATION

The applications for use of a UPC scanner to record home food inventory are varied. The output of the UPC scanner provides a complete list of food items in the home. Researchers can use this information to test hypotheses of food security, food availability, and the nutritive quality of the home food inventory. Furthermore, researchers can provide the list of foods in the home to the family caretaker to garner food frequency specific to the foods in the home. The UPC scanner provides a clear and

objective measure of foods in the home. This technique may also be useful in the clinical setting for dietitians and nutrition experts. Nutrition recommendations can be catered to family needs after assessing the food inventory within home. Additionally, product UPC symbols could be a critical addition to current nutrient databases. The addition of this category would allow for more complete assessment of the nutrition adequacy of foods in the home and could provide a more efficient method of analyzing the nutritive adequacy of foods available to a family.

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TABLES AND FIGURES

Figure 1: Household food system: food procurement options for limited-resource families

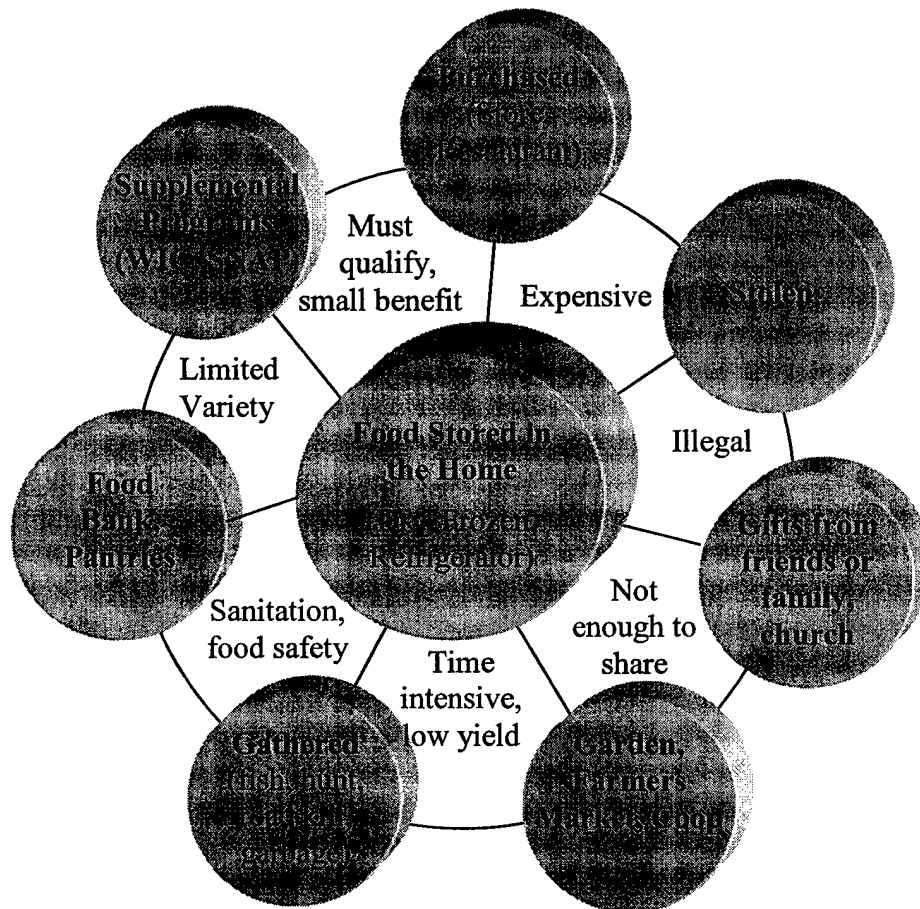


Figure 2: Percent of food items scanned that did not match the line-item inventory—by food group

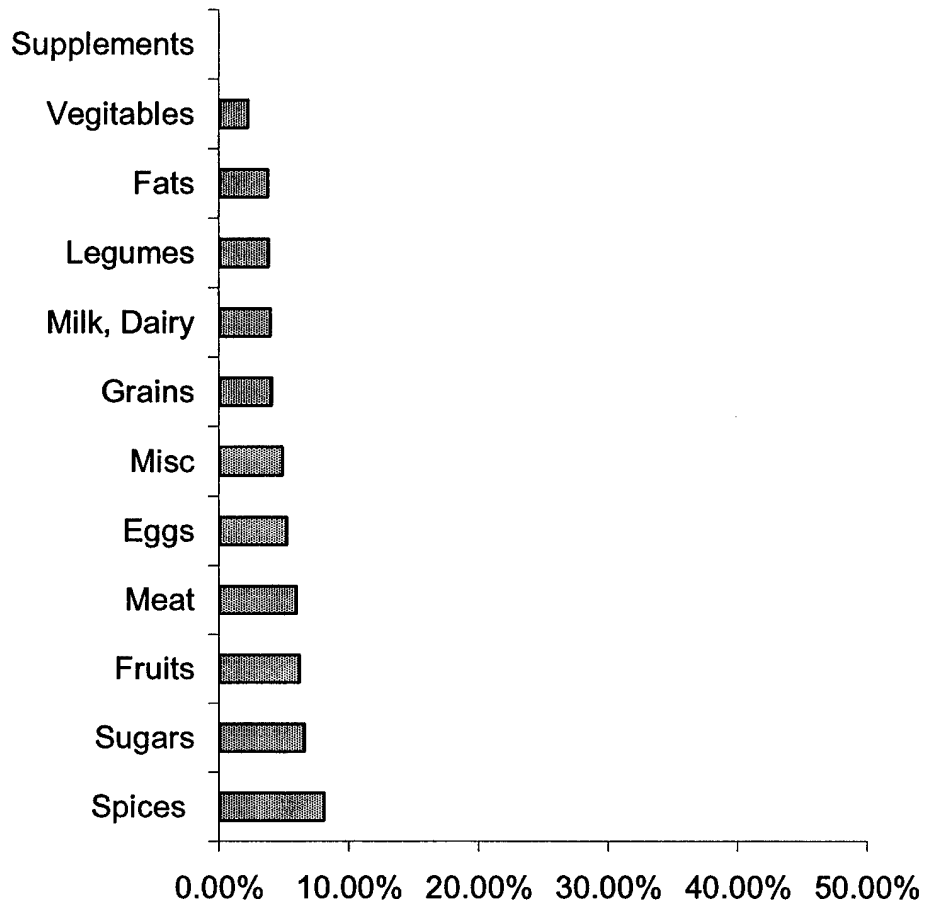


Table 1: USDA food groups—distribution of foods in the home inventory from line-item inventory

USDA Food Group†	Size Rank	% Size of Inventory‡	Number of Foods
Grain Products	1	23.6	4686
Vegetables	2	19.4	3856
Meat, Fish, Poultry	3	16.2	3218
Sugars, Sweets	4	11.1	2199
Legumes, Dry Beans	5	9.5	1876
Peas, Nuts			
Fruits	6	6.7	1330
Milk and Dairy Products	7	6.6	1314
Fats, Oils	8	2.7	533
Misc.	9	2.2	438
Spices	10	1.3	251
Eggs	11	0.6	128
Supplements	12	0.0	5
		100%	

† U.S. Department of Agriculture, Agricultural Research Service. 2003. USDA National Nutrient Database for Standard Reference, Release 15. Nutrient Data Laboratory Home Page, http://www.nal.usda.gov/fnic/foodcomp/Data/SR15/asc/fd_group.txt

‡ % Size of Inventory refers to the proportion that this food group represented

Table 2: USDA food groups—distribution of foods in the home inventory from UPC Scanner report

USDA Food Group	Size Rank	% Size of Group	# of foods Scanned
Grain Products	1	28.3	1673
Vegetables	2	19.1	1133
Meat, Fish, Poultry	3	13.0	770
Legumes, Dry Beans	4	11.4	677
Peas, Nuts			
Sugars, Sweets	5	10.8	637
Milk and Dairy Products	6	6.3	375
Fruits	7	4.6	273
Fats, Oils	8	3.1	186
Misc.	9	1.7	102
Spices	10	1.3	74
Eggs	11	0.3	19
Supplements	12	<u>0.0</u>	1
		100%	

Table 3: Scanner accuracy by USDA food group

USDA Food Group	% Correctly Matched†	Number Matched	% Incorrectly Matched‡	Number Missed
Supplements	100	1	0	0
Vegetables	97.7	1107	2.3	26
Fats, Oils	96.2	179	3.8	7
Legumes, Dry Beans	96.2	651	3.8	26
Peas, Nuts				
Milk and Dairy Products	96.0	360	4.0	15
Grain Products	95.9	1605	4.1	68
Misc.	95.1	97	4.9	5
Eggs	94.7	18	5.3	1
Meat, Fish, Poultry	94.0	724	6.0	46
Fruits	93.8	256	6.2	17
Sugars, Sweets	93.4	595	6.6	42
Spices	91.9	68	8.1	6

† Refers to the percent of those foods scanned that correctly matched to the corresponding food in the line-item inventory

‡ Refers to the percent of those foods scanned that incorrectly matched to the corresponding food in the line-item inventory

Appendix A: Calculating the Check Digit on a product UPC

The last digit of the UPC code is called a check digit. This digit lets the scanner check to assure it scanned the product UPC correctly. The check digit calculation below is based on the following UPC number

UPC = 63938200039

1. Add together the value of all of the digits in odd positions (digits 1, 3, 5, 7, 9 and 11).
 $6 + 9 + 8 + 0 + 0 + 9 = 32$
2. Multiply that number by 3.
 $32 * 3 = 96$
3. Add together the value of all of the digits in even positions (digits 2, 4, 6, 8 and 10).
 $3 + 3 + 2 + 0 + 3 = 11$
4. Add this sum to the value in step 2.
 $96 + 11 = 107$
5. Take the number in Step 4. To create the check digit, determine the number that, when added to the number in step 4, is a multiple of 10.
 $107 + 3 = 110$
6. The check digit is therefore 3.

Therefore the resulting UPC that would appear on the final product would be 639382000393

Each time an item is scanned this calculation is performed by the scanners computer chip. If the check digit calculated is different from the check digit it reads, the scanner knows that something went wrong and the item needs to be rescanned.

Appendix B: Sample Scanner Output

- 1 ● Nabisco Cream Of Wheat Microwaveable 2.5 Minute Wheat Farina Hot Cereal 28 oz Box
- 1 Stop & Shop Microwaveable Quick Oats Hot Cereal 42 oz Canister
- 1 ● General Mills Cheerios OAT Cereal 15 oz Box
- 1 ● Post Grape Nuts Whole Wheat & Barley Cereal 14 oz Box
- 1 Price Rite Corn Cereal 18 oz Box
- 1 Kelloggs Special K Red Berries Rice And Wheat Cereal 12 oz Box
- 1 ● General Mills Multi Grain Cheerios Multi Grain Cereal 16 oz Box
- 1 ● General Mills Cheerios Whole Grain Oat Cereal 20 oz Box

Condiments

- 1 Stop & Shop POURABLE Yellow Mustard 20 oz Plastic Bottle
- 1 La Cena PITTED Pimento Stuffed Spanish Green Olive 10 oz Jar
- 1 ● Guldens SPREAD Spicy Spicy Brown Mustard 12 oz Plastic Bottle
- 1 ● McCormick Imitation Bacon BIT Salad Topping 3.25 oz Bottle
- 1 ○ Hellmanns Spreadable Mayonnaise 32 oz Jar
- 2 ● Frenchs POURABLE Yellow Mustard 16 oz Plastic Bottle
- 1 Price Rite Pancake/Waffle Syrup 24 oz Plastic Bottle
- 1 ● Wishbone Just 2 Good Low Fat Country Italian Herb Salad Dressing 16 oz Plastic Bottle
- 1 Wishbone Just 2 Good Low Fat Deluxe French Salad Dressing 16 oz Plastic Bottle
- 1 Heinz CLASSIC Spears Dill Pickle 24 oz Jar

Dairy

- 1 Garelick Farms Pasteurized Homogenized Whole Milk 128 oz Plastic Container

Ethnic Section

- 6 ● Goya Spanish Tomato Sauce 8 oz Can
- 1 Goya SOFRITO Sauce 12 oz Jar
- 1 Pasta Growers Long Lasagna Pasta 16 oz Box
- 1 Luigi Vitelli Long And Thin Angel Hair Pasta 16 oz Plastic Wrapped
- 1 Goya FEDELINI & FIDEO Pasta 12 oz Bag
- 1 ● San Giorgio Thin Long Spaghetti Pasta 16 oz Box
- 1 Stop & Shop SHELL Macaroni Pasta 12 oz Box
- 1 ● Ronzoni RECTANGLE Lasagna Pasta 8 oz Box

Frozen Section

- 1 Sea Wave Uncooked CALAMARI 16 oz Box

Appendix C: Line-Item Inventory Collection Form

Food Inventory Item Please Print the Name of Food Item and Brand if Possible Example: "Kellogg's Fruit Loops or La Cerna Oatmeal Paste"		Frequency of Use	Do you Eat This Food 0/1/2/3/4+ times per wk	PLEASE DO NOT FILL OUT THIS AREA																						
				Food Group						Hydrating	Fe Content	Ascorbic Acid	Fortificants													
				G	F	V	M	D	T	H/ N	L	M	B	L	M	B	B	P	K	P	P	C	F	ED	C	O
1			0 1 2 3 4+																							
2			0 1 2 3 4+																							
3			0 1 2 3 4+																							
4			0 1 2 3 4+																							
5			0 1 2 3 4+																							
6			0 1 2 3 4+																							
7			0 1 2 3 4+																							
8			0 1 2 3 4+																							
9			0 1 2 3 4+																							
10			0 1 2 3 4+																							
11			0 1 2 3 4+																							
12			0 1 2 3 4+																							
13			0 1 2 3 4+																							
14			0 1 2 3 4+																							
15			0 1 2 3 4+																							

UNIVERSITY OF CONNECTICUT
Storrs, Connecticut

THE GRADUATE SCHOOL

REPORT ON THE FINAL EXAMINATION FOR THE MASTER'S DEGREE

This report shall be submitted to the Graduate Records Office, Box U-6-B, by the major advisor immediately following the examination. If both written and oral sections are given, or if the examination is given in several parts, one report should cover the entire examination. The report should be submitted whether the examination, as a whole, has been passed or failed. The report may be prepared in duplicate, but only the original should be submitted. The second copy is to be retained by the major advisor.

Name of student Jim Weinstein 154-80-9073
Soc. Sec. #

1. Written section, if any

a. Date(s) given Jan 16, 2003

b. Faculty members participating Dr. Maria-Luz Fernandez, Dr. Valerie Duffy,
Dr. Lammi Keefe, Dr. Ann Ferris, Dr. Sung Koo, Dr.
Nancy Rodriguez all departmental faculty,

2. Oral section, if any

a. Date(s) given 5/9/03

b. Faculty members participating Ann M. Ferris, C. Lammi-Keefe, Valerie
Duffy, Maria-Luz Fernandez, Sung Koo, Nancy
Rodriguez

3. Results of the entire examination High Pass

Comments, if any

(Indicate whether a reexamination is recommended.)

Date 5/9/03 Signatures:

Major Advisor Ann M. Ferris

Associate Advisor Valerie Duffy

Associate Advisor Valerie Duffy

(Associate Advisor)